Endogenous Growth Amidst the Turbulent Times: Contemplative Approaches to Preserve Economic Resilience in the Face of Global Uncertainty

Wahyu Aulia[a], Ivan Sudibyo[b]

[a] *Universitas Andalas, wahyuauliaa13@gmail.com*

[b] *Universitas Indonesia, ivansudibyo14@gmail.com*

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A B S T R A C T

The surveillance of economic health amidst global uncertainty is crucial. It provides an understanding of macroeconomic conditions that can be used as a basis for formulating public policies and developing appropriate strategies to address economic issues. This quantitative research aims to investigate endogenous growth strategies that can be used to achieve sustainable economic resilience in the face of global economic uncertainty post-COVID-19, particularly through R&D. The dataset employed in this scholarly investigation is derived from the World Bank, spanning the years from 1990 to 2022, and is specifically relevant to the context of Indonesia. The research method employed is the Autoregressive Distributed Lag (ARDL) approach. This method analyzes the impact of independent variables such as FDI Net Inflows, Human Development Index (HDI), Life Expectancy, and R&D on Total Factor Productivity (TFP), which is a measure of a country's economic efficiency. The results show that Life Expectancy, FDI Inflows, and R&D have a significant positive impact on TFP. Therefore, policies that support R&D and technological innovation are often considered factor to achieving sustainable long-term economic growth.

A B S T R A K

Pengawasan terhadap kesehatan ekonomi di tengah ketidakpastian global sangatlah penting. Hal ini memberikan pemahaman tentang kondisi makroekonomi yang dapat digunakan sebagai dasar untuk merumuskan kebijakan publik dan mengembangkan strategi yang tepat untuk mengatasi masalah ekonomi. Penelitian kuantitatif ini bertujuan untuk menyelidiki strategi pertumbuhan endogen yang dapat digunakan untuk mencapai ketahanan ekonomi yang berkelanjutan di tengah ketidakpastian ekonomi global pasca COVID-19, khususnya melalui R&D. Dataset yang digunakan dalam penelitian ilmiah ini berasal dari Bank Dunia, mencakup tahun 1990 hingga 2022, dan secara khusus relevan dengan konteks Indonesia. Metode penelitian yang digunakan adalah pendekatan Autoregressive Distributed Lag (ARDL). Metode ini menganalisis dampak variabel independen seperti Arus Masuk Bersih FDI, Indeks Pembangunan Manusia (IPM), Harapan Hidup, dan R&D terhadap Total Factor Productivity (TFP), yang

merupakan ukuran efisiensi ekonomi suatu negara. Hasil penelitian menunjukkan bahwa Harapan Hidup, Arus Masuk FDI, dan R&D memiliki dampak positif yang signifikan terhadap TFP. Oleh karena itu, kebijakan yang mendukung R&D dan inovasi teknologi sering kali dianggap sebagai faktor untuk mencapai pertumbuhan ekonomi jangka panjang yang berkelanjutan.

INTRODUCTION

Economic health monitoring plays an important role in public policy-making and economic decision-making. Firstly, it provides an in-depth understanding of macroeconomic conditions, such as GDP growth and inflation. The data and analysis obtained from this monitoring provide the basis for the government to design effective fiscal and monetary policies to achieve national economic goals, such as maintaining price stability and promoting economic growth. The study by Blanchard et al. (2019) highlights the importance of accurate and continuous monitoring of economic indicators to support appropriate policymaking.

The importance of maintaining the health and stability of the economy through its growth is a reference in public policymaking because stable economic growth helps achieve the main goals in society, namely stable GDP growth, maintaining low unemployment rates, and controlling inflation. Economic stability is important because wide fluctuations in GDP can create uncertainty, reduce incentives for private investment, be a reason for capital flight, and create social and political instability in society (Altarawneh et al., 2020).

In addition, monitoring economic health enables early detection of risks and imbalances in the economy. By keeping a constant eye on economic developments, the government can identify potential problems such as trade imbalances, asset bubbles, or excess debt that could threaten economic stability. Studies by Obstfeld and Rogoff (2021) emphasizes the need for careful monitoring of economic risk factors to prevent costly economic crises.

Currently, countries around the world are facing post-Covid economic uncertainty. Post-Covid economic uncertainty during the worldwide recovery is a significant concern. Several studies show the Global Economic and Environmental Policy Uncertainty (GEPU) index, important for measuring global economic policy uncertainty, is expected to remain stable or decrease post-pandemic, and help economic and environmental recovery (Hui et al., 2022). The unprecedented impact of COVID-19 has led to a prolonged global recession, necessitating the restructuring of economic regulatory mechanisms and accelerated digitalization for economic revival (Ineza, 2022). In addition, the uncertainty caused by the pandemic has increased challenges in service recovery satisfaction, emphasizing the need for effective recovery strategies amid ongoing uncertainty (Kowoon, 2023). Addressing

inequalities in healthcare access and global support for low-income countries struggling with limited resources are important aspects of post-Covid economic recovery (Evgenii et al., 2021). Efforts to build investor and consumer confidence, disengage from speculative markets, and enhance multilateral cooperation are critical to navigating the uncertain economic landscape during the post-COVID recovery phase.

Economic resilience plays an important role in responding to large shocks such as the pandemic, as seen in China's GDP recovery efforts one. Unequal distribution of resources and access to healthcare and vaccines exacerbates economic disparities globally. To achieve inclusive growth and recovery, it is important to strengthen public health systems, protect vulnerable populations, and implement policies that increase economic resilience. Post-Covid economic recovery should focus on building a future-ready, resilient society and promoting equitable and sustainable development (Jiang et al., 2022).

In the context of post-Covid-19 recovery, Romer's (1986) theory, which emphasizes technological progress and knowledge accumulation, also known as R&D, is becoming increasingly relevant. This theory implies that even in challenging situations, the infinite potential of knowledge can drive economic recovery. This emphasizes the importance of investing in education, skills development, and innovation. Moreover, the pandemic has accelerated the shift to sectors that rely heavily on innovative ideas, suggesting that creating an environment that fosters the growth and application of knowledge is crucial for economic recovery and labor market resilience.

Further economic diversification becomes crucial in facing global economic challenges, including post-Covid-19 uncertainties. By reducing reliance on specific sectors, Indonesia can enhance its economic resilience against external shocks and promote inclusive and sustainable growth. This strategy is vital for creating a diverse economic environment resilient to global market fluctuations, aligning with efforts to strengthen the national economic foundation (Zen, 2012).

Simultaneously, a focus on economic diversification is relevant to increasing investment in research and development (R&D). As part of economic diversification efforts, R&D can serve as a key driver for innovation and value creation across various economic sectors. Initiatives such as R&D infrastructure funded through Sukuk by the Indonesian government (Putera et al., 2022) demonstrate a commitment to developing national innovation capacity, crucial for achieving stable and sustainable economic growth in the future.

R&D development in Indonesia during 2022-2023 is crucial amid economic

uncertainty (Wang et al., 2023; Anas et al., 2022). Policymakers should focus on stable economic policies to promote R&D amidst uncertainty for long-term prosperity. During the pandemic, the country's R&D sector faced significant obstacles, including insufficient international research output and decreased budget allocations. However, at this time the Indonesia Government has taken strategic steps to invest in R&D infrastructure through Sukuk financing, focusing on diversifying the types of infrastructure financed to align with the needs of Ministries/Agencies and Local Governments (Putera et. al 2022). In addition, corporate governance plays an important role in influencing R&D investment decisions, with factors such as internal management, independent commissioners, and corporate resources having a positive impact on R&D costs. Despite challenges such as the impact of the COVID-19 pandemic on R&D spending decisions, there is a clear emphasis on maintaining competitive advantage through R&D activities in Indonesia (Nathanael & Murhadi (2022). This concerted effort reflects a commitment to drive innovation and development in the country.

This study uses the theory of Romer (1986) who is one of the pioneers in endogenous growth models. Romer modeled that technological progress depends on the total amount of knowledge investment. Total knowledge investment is determined by the individual decisions of each company. Investment in knowledge can be done through the development of the R&D sector. Investment can be done through additional company capital or increased individual research (which will increase private knowledge). The increase in knowledge owned by the company will be higher if the company already has a high stock of private knowledge.

Endogenous growth theory emphasizes the dynamic interaction between capital, labor, and innovation, for economic stability. In turbulent times characterized by global risk and uncertainty, strategies for economic stability are essential. The current economic landscape, affected by the contradictions of globalization and localization, necessitates a shift towards nationally rooted economic development strategies (Grytsenko, 2022; Julia, 2020). The importance of monitoring health risks such as COVID-19 on labor capital and promoting a risk-free work environment is essential for sustainable growth. By integrating innovative technological solutions and fostering a culture of learning and prevention, economies can navigate turbulent times and achieve sustainable development (Julia, 2020). The study by Gumus et al. (2015) conducts a detailed empirical examination of the correlation between research and development (R&D) spending and economic growth, and explores whether this correlation varies based on the level of development. The study uses data from 52 countries spanning from 1996 to 2010 and applies a dynamic panel data model. The findings reveal that R&D expenditure has a substantial and positive impact on

economic growth for all countries over an extended period, aligning with existing literature. For developing countries, the impact is initially weak but intensifies over time. This study contributes fresh empirical evidence to the field. Their empirical results suggest proposing that for developing countries more resources should be allocated on R&D activities for speeding up growth and economic performance.

The purpose of this study is to investigate endogenous growth strategies that can be used to achieve sustainable economic stability amidst post-Covid-19 global economic uncertainty specifically through R&D. By integrating endogenous growth theory, particularly the concept put forward by Romer (1986), this research aims to understand how the dynamic interaction between capital, labor, and innovation can be the foundation in developing effective strategies to respond to complex economic challenges in this post-pandemic era. Through this research, it is hoped that valuable insights will be found that can guide policymakers in designing appropriate measures to promote stable and sustainable economic growth in the future.

LITERATURE REVIEW

The neo-classical growth model developed by Solow (1956) and Swan (1956) shows that technological progress is an exogenous factor in the economy. Meanwhile, the endogenous growth model of Romer (1986), Lucas (1988), and Grossman and Helpman (1991a) suggest that technological progress is an endogenous factor. The endogenous growth model argues that technological progress results from innovation, trade, competition, and education, among others. In particular, it emphasizes the role of human capital and R&D as push drivers of growth (Madsen, Saxena, and Ang, 2010; Ang and Madsen, 2011). The main limitation of early endogenous growth models (first generation) was that they were inconsistent with the results obtained in some countries (Madsen, 2008).

The failure of first-generation endogenous growth models to explain economic growth gave rise to second-generation endogenous growth models, namely semi-endogenous models (Kortum, 1997; Segerstrom, 1998) and Schumpeter growth models (Aghion and Howitt, 1998; Peretto, 1998; Young, 1994; Howitt, 2000). The semi-endogenous growth model relaxes the assumption of constant returns to knowledge, while the Schumpeter growth model maintains the assumption of constant returns to knowledge but assumes an increase in innovation complexity.

Subsequently, semi-endogenous growth models have been widely used to explain the growth of industrialized countries, as in Coe and Helpman, 1995; Zachariadis, 2003, 2004; Kneller and Stevens, 2006; Ha and Howitt, 2007; Madsen, 2007, 2008. Despite its popularity, semi-endogenous growth models have not been

widely used to understand economic growth in emerging countries, except by Madsen, Saxena, and Ang (2010) and Ang and Madsen (2011). Madsen, Saxena, and Ang (2010) proved that India's economic growth over the last five decades was driven by research intensity, a finding consistent with the predictions of Schumpeter's growth theory. While Ang and Madsen (2011) strongly support Schumpeter's growth theory, but only limitedly support semi-endogenous growth theory. The results of the study stated that R&D has a essential role in the stunning growth of Asian economies but did not include Indonesia as a research sample so further research needs to be done specifically for Indonesia.

Theoretical framework

The production function (Ghosh, T., et.all., 2021) is given by:

$$Y = A^{\sigma} K^{\alpha} (hL_Y)^{1-\propto} e^{ha}, 0 <\propto< 1; \ (1)$$

where Y is output, A is technology level, K is physical capital, α is the share of physical capital, L_Y is the labor employed in producing output, and h is human capital per person. e^{ha} measures the externality associated with average human capital of the workforce, ha. The output is associated with constant returns to scale with respect to the physical capital and labor (rivalrous inputs). The output is associated with increasing returns to capital, labor and ideas together, where $\sigma > 0$ captures the degree of increasing returns associated with ideas. Similarly, the output is associated with increasing returns with respect to capital, labor and human capital together (Lucas (1988)). Note that the time subscripts for all the variables are suppressed for simplicity.

The production function for ideas is given by:

$$A^{\cdot} = \gamma(hLA/B)A\hat{}\varphi, \varphi > 0; \ (2)$$

According to equation (2), new ideas produced at any point in time depend on the effective research effort(hL_A) per variety of consumption goods B. h is human capital per person and L_A is the total number of researchers; and existing stock of ideas(A). φ represents the externalities associated with R&D. For simplicity, we assume that B = L^B, where L = L_A + L_Y. In our model, human capital directly affects production by making output-producing workers more productive (shift in the production frontier) and indirectly influencing output by increasing the competitiveness of researchers (efficiency effects). Similarly, R&D is shown to have scale effects (captured through φ in equation (2)) and efficiency effects (captured by A in equation (1)).

According to the first generation fully endogenous growth models (Romer (1990) and Grossman and Helpman (1991b)), every unit of research effort produces a proportionate increase in the stock of knowledge, that is, φ = 1: It implies that if we keep increasing the stock of knowledge increasing the resources devoted to R&D

(increasing the number of researchers or increasing the R&D expenditure), we can achieve an exponential increase in per capita output. To eliminate this scale effects associated with first generation endogenous growth models, the semi-endogenous growth models of Jones (1995) and Kortum (1997) and Segerstrom (1998) assume, $\varphi < 1$. Increasing knowledge stock by increasing resources devoted to say R&D workers only has a sustained short-term impact on per capita output, while long-term effects are unsustainable. Note that both endogenous growth models of the first generation and semi-endogenous growth models assume $\beta = 0$.

The Schumpeterian growth models (Aghion and Howitt, 1998) proposed an alternative way to eliminate the scale effects. They retained the assumption of $\varphi = 1$ from the first generation fully endogenous growth models. But they incorporated the assumption of $\beta = 1$, that is, the variety of consumption goods is proportional to the total labor force.

Simply increasing the number of R&D workers is not enough to generate long run growth effects. Sustained increase in output per capita requires an increase in R&D intensity, i.e. an increase in the number of researchers per product/sector or, aggregate R&D expenditures per product/sector, etc.

As discussed before, FDI shifts up the host economy's production frontier as well as increases the country's production efficiency (Yao and Wei (2007)). So, the shift in the production frontier due to the presence of FDI is now captured by the 'FDI' term in equation (3): And the increase in production efficiency due to FDI is captured by equation (4) where the rate of arrival of new ideas, δ; is an increasing function of FDI, $\delta = \gamma(\text{FDI})$, $\gamma'(\text{FDI}) > 0$. FDI is the most direct and efficient way of acquiring new technologies and fastens the arrival of new ideas captured by $\tilde{A} > A$ for the host nation.

$$Y = \tilde{A}^{\sigma} K^{\alpha} (hL_Y)^{1-\alpha} e^{ha+FDI};\ 0 < \alpha < 1 \quad (3)$$

$$\dot{\tilde{A}} = \delta(\text{hL}_A/\text{B})A^{\varphi}, \varphi > 0; \quad (4)$$

Furthermore, the technological diffusion through the channels of technology-intensive imports from R&D-intensive countries (captured by R_t^f in our analysis) can play an important role in influencing productivity growth (Coe and Helpman (1995) and Madsen et al. (2010) etc.). However, the spillover variable will only appear in equation (4) and not equation in (3) as it will only exhibit efficiency effects. In equation (4), in addition to FDI, the rate of arrival of new ideas, δ; is an increasing function of spillover variable as well, $\delta = \gamma(FDI, R_t^f), \gamma_1, \gamma_2 > 0$.

In endogenous growth theory, the calculation process involves the use of simulation. These simulations are used to predict and calculate the variables that are expected to be optimized. This is an important part of the process of analyzing and understanding how economic growth can be affected by internal factors.

RESEARCH METHODS

This study uses a method that can be used to analyze the relationship between factors affecting endogenous economic growth in the context of global uncertainty. This study adopts a quantitative approach using data from 1990 to 2022 obtained from the World Bank and Penn World Table. The dependent variable in this analysis is Total Factor Productivity (TFP), which is a measure of a country's economic efficiency. The independent variables included in the model are FDI Net Inflows, Human Development Index (HDI), Life Expectancy, and R&D. The method of analysis applied in this study is Autoregressive Distributed Lag (ARDL) which allows to examine the long-run and short-run relationship between the variables.

The application of the ARDL method allows the researcher to test the hypotheses surrounding the relationship between TFP and the mentioned independent variables, taking into account the possibility of a dynamic relationship in the long run. This approach also takes into account the long-run and short-run effects of the independent variables on TFP, thus providing a more holistic understanding of the factors affecting economic growth in the context of global uncertainty. The researcher also conducted a stationarity test, namely through the Augmented Dickey-Fuller (ADF) test. The research model used is the ARDL model according to Ghosh, T., et. al., (2021) and Kripfganz, S., et.al, (2023):

$$\begin{aligned}\Delta TFP_t = {} & \alpha_0 + \sum \beta_i \Delta TFP_{\{t-i\}} + \sum \gamma_j \Delta FDI_{\{t-j\}} + \sum \delta_k \, \Delta R\&D_{\{t-k\}} \\ & + \sum \varepsilon_l \Delta HC_{\{t-l\}} + \theta_1 TFP_{\{t-1\}} + \theta_2 FDI_{\{t-1\}} + \theta_3 \, R\&D_{\{t-1\}} \\ & + \theta_4 HC_{\{t-1\}} + u_t\end{aligned}$$

Description:

- Δ is the first difference operator.
- TFP_t is the Total Factor Productivity at time period t.
- FDI_t is Foreign Direct Investment in time period t.
- $R\&D_t$ is the R&D expenditure in time period t.
- HC_t is human capital at time period t.
- α_0 is a constant.

- $\beta_i, \gamma_j, \delta_k$ and ε_l is the short-run coefficient.
- $\theta_1, \theta_2, \theta_3$ dan θ_4 is the long-run coefficient.
- u_t is the error term at time period t.
- $i, j, k,$ and l is lag-order.

Thus, the ARDL method was chosen for its ability to capture the complex dynamics between these variables and provide a solid analytical foundation for understanding economic stability strategies amid global uncertainty

RESULT AND DISCUSSION

This study uses Total Factor Productivity (TFP) as the dependent variable. TFP is a measure of the overall efficiency of production in an economy. TFP growth is a key indicator for evaluating growth models (Nguyen, 2022). The use of TFP as a dependent variable makes it possible to measure the overall efficiency of production. Moreover, in periods of global uncertainty, TFP can give an idea of how well a country's economy can adjust to these changes and still maintain a stable growth rate. This research emphasizes endogenous growth which is a very important factor in the economy that can increase long-run growth. Total Factor Productivity (TFP) is indeed an important factor contributing to long-run economic growth as it signifies the efficiency in utilizing all factors of production, including innovation and technology (Nguyen, 2022). Thus, TFP is a relevant and important choice as the dependent variable in this study as it can provide a deep understanding of how endogenous growth strategies can help achieve economic stability amid global uncertainty.

In addition, the independent variables used in the form of HDI, life expectancy, R&D, and FDI inflows are factors that can directly or indirectly affect the efficient use of factors of production in the economy. An increase in HDI and life expectancy, for example, can improve the quality of labor and reduce absenteeism due to illness, which contributes to an overall increase in productivity. Economic theory suggests that human capital in the form of healthy worker contributes to economic growth. Life expectancy is used as a proxy for the health of the work force. We argue that higher life expectancy is generally associated with better health status and lower morbidity. In addition, investments in R&D and FDI inflows can introduce new technologies and more efficient management practices, which can increase efficiency and innovation in production. Thus, the relationship between these independent variables also helps formulate strategies to achieve economic stability in the face of uncertain global challenges.

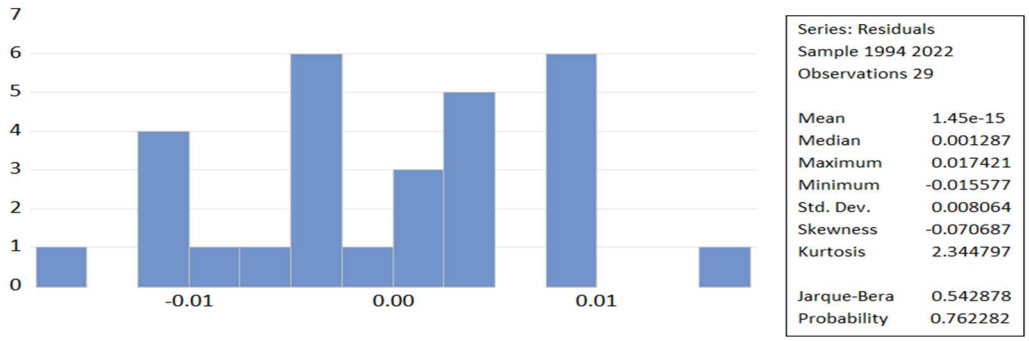
4.1. Data Analysis Results

4.1.1. Classical Assumption Test

Normality Test

The significance test of the effect of the independent variable on the dependent variable will be valid if the research data is normally distributed. To find out whether the residuals are normally distributed or not, a normality test is required. The normality test in this study was carried out using the Jarque-Bera method.

Figure 1. Normalization Test Results



Source: Data processed by Eviews (2024)

The normality test results in the figure above produce a JB number of 0.542878 with a probability of 0.762282. The test results show that the JB probability value is greater than α = 5%. So, it can be concluded that this research data is normally distributed.

Autocorrelation Test

The autocorrelation test aims to examine the correlation between the error terms of one observation with those of another observation. This serial correlation test is conducted using the Breusch-Godfrey Serial Correlation LM Test method. The results of the autocorrelation test can be seen in the table below.

Table 1. Autocorrelation Test Results

F-Statistic	4.479516	***Prob. F (2.3)***	0.1256
Obs * R-Squared	21.76516	***Prob Chi-Square(2)***	0.0000

Source: Data processed by Eviews (2024)

Based on the test results in Table 4.1, it can be seen that the probability value of F is 0.1256, which is greater than α = 5%. This indicates that there is no autocorrelation problem in the research model.

Heteroskedasticity Test

The heteroskedasticity test in this study uses the Breusch-Pagan-Godfrey method by comparing the probability value of Obs*R-Square with its critical value (α = 5%).

Table 2. Heteroscedasticity Test Results

F-Statistic	3.403838	***Prob. F (23,5)***	0.0886
Obs * R-Squared	27.25906	***Prob Chi-Square (23)***	0.2451
Scaled explained SS	0.544856	***Prob Chi-Square (23)***	1.0000

Source: Data processed by Eviews (2024)

Based on Table 4.2, it can be seen that the heteroskedasticity test results using the Breusch-Pagan-Godfrey method show that the probability value of F (0.0886) is greater than its critical value (α = 5%). This indicates that the ARDL model exhibits homoscedasticity, meaning there is a uniform variance of residuals across all observations.

4.1.2. Stationarity Test

The first step in testing using the ARDL model is the stationarity test. In this study, the stationarity test is conducted using the unit root test proposed by Dickey and Fuller, known as the Augmented Dickey-Fuller (ADF) test. The results of the ADF stationarity test can be seen in the table below.

Table 3. Stationarity Test Results

Variable	ADF Statistic	Critical Value			Prob	Description
		1%	5%	10%		
TFP	-4.082761	-3.661661	-2.960411	-2.619160	0.0035	Stationer
FDI-Inflow	-5.361034	-3.661661	-2.960411	-2.619160	0.0001	Stationer
HDI	-4.463087	-3.661661	-2.960411	-2.619160	0.0013	Stationer
Life Expectancy	-4.117225	-3.661661	-2.960411	-2.619160	0.0032	Stationer
R&D	-5.994635	-3.661661	-2.960411	-2.619160	0.0000	Stationer

Source: Data processed by Eviews (2024)

The stationarity test results in Table 4.3 above indicate that all research variables are stationary at the level stage. This is evidenced by the ADF statistic values being smaller than the critical values at 1%, 5%, and 10%, allowing for the next stage of testing to be conducted.

4.1.3. Cointegration Bound Test

The cointegration test before performing the ARDL test is to examine whether the variables in the model have a stable long-term relationship. Cointegration indicates that although these variables may have short-term fluctuations, there is a long-term relationship that maintains equilibrium over a longer period. This is crucial in the context of the ARDL test because the ARDL model requires cointegration among its variables. Thus, the cointegration test helps ensure that the ARDL model constructed will provide consistent and valid estimates in analyzing the long-term relationships between these variables**.**

Table 4. Cointegration Bound Test Results

Test Statistic	**Value**	**K**
F- Statistic	3.017526	4

Significancy	***I (0) Bound***	***I (I) Bound***
10%	2.200	3.090
5%	2.560	3.490
1%	3.290	4.370

Source: Data processed by Eviews (2024)

The results of the Cointegration Bound Test in the table above show that the F-statistic value (3.017526) is greater than the I(0) and I(1) values at the 10% significance level. The ARDL model estimation, indicated by the significant value of the F-test Bounds statistic, demonstrates the presence of a long-term cointegration between TFP and the explanatory variables.

Table 5. Error Correction Test Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ*	0.203246	0.033776	6.017500	0.0001
D(TFP(-1))	-1.065039	0.263593	-4.040471	0.0024
D(LIFE_EXPECTANCY(-1))	0.099820	0.013721	7.275042	0.0000
D(HDI(-1))	-7.525675	1.293210	-5.819374	0.0002
D(FDI_INFLOWS(-1))	0.049919	0.008881	5.620835	0.0002
D(RD(-1))	0.254346	0.090289	2.817019	0.0183

Source: Data processed by Eviews (2024)

The author uses the error correction test to measure long-run cointegration for each variable (Ghosh, T., et al., 2021). The error correction test results for each coefficient show that all coefficients indicate a significant impact on the long-run cointegration of the model.

4.1.4. Multicollinearity Test

Table 6. Multicollinearity Test Results

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
D(FDI_INFLOWS(-1))	2.70E-05	1.173516	1.172842
D(HDI(-1))	3.239579	7.365408	2.756876
D(LIFE_EXPECTANCY(-1))	0.000147	2.597482	2.474146
D(RD(-1))	0.024106	1.126554	1.071872
C	0.000115	4.803267	NA

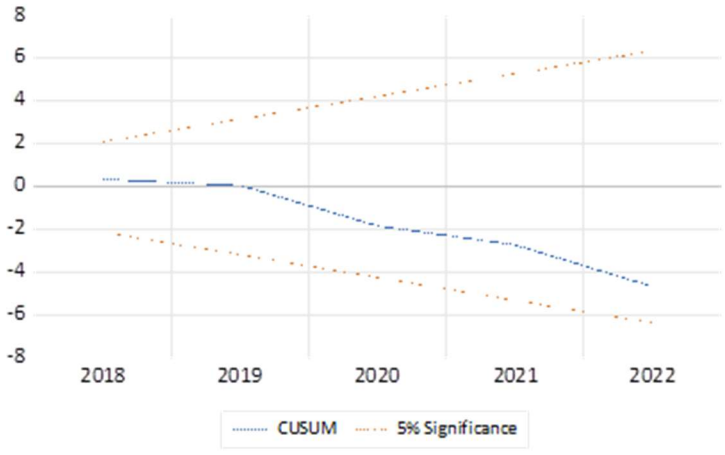
Source: Data processed by Eviews (2024)

Based on the provided data, it can be concluded that there is no multicollinearity present in this model. This conclusion is drawn from the Variance Inflation Factor (VIF) test results, where all variables exhibit VIF values below the commonly used threshold of 5 or 10, indicating a lack of serious multicollinearity. Therefore, the model is deemed appropriate for further analysis and interpretation. This rigorous testing ensures the reliability and validity of the model, enhancing the robustness of the findings derived from it.

4.1.5. CUSUM Stability Test

The CUSUM (Cumulative Sum) test in ARDL (Autoregressive Distributed Lag) models serves to assess the stability of coefficients over time by analyzing the cumulative sum of the residuals. This test helps identify structural breaks or changes in the relationship between dependent and independent variables throughout the sample period. A stable CUSUM plot indicates consistent coefficients, ensuring the reliability of long-term forecasts and policy analyses derived from the ARDL model.

Figure 2. CUSUM Stability Test Results



Source: Data processed by Eviews (2024)

Based on the stability evaluation conducted using the Cumulative Sum (CUSUM) method, the null hypothesis (H0) stating significant changes at a 5% significance level is rejected. This indicates that the empirical model under study demonstrates stability characteristics throughout the observation period. Therefore, it can be concluded that the empirical model exhibits stability during the observation period. Thus, the alternative hypothesis (H1) stating that the model is stable is accepted.

4.1.6. Results of Autoregressive Distributed Lag (ARDL) Model Estimation

The conclusions drawn from the Cointegration Bound Test indicate the presence of a long-term relationship between variables. Therefore, for the next testing stage, the estimation of the ARDL model can be conducted.

Table 7. ARDL Estimation Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
TFP(-1)	0.13820	0.36863	0.37491	0.72310
TFP(-2)	0.28870	0.36796	0.78459	0.46821
TFP(-3)	0.30705	0.291642	1.05284	0.34060
TFP(-4)	0.46927	0.274357	1.71046	0.14786
LIFE_EXPECTANCY	-0.01684	0.01196	-1.40757	0.21828
LIFE_EXPECTANCY(-1)	0.052404	0.019821	2.64375	**0.04576**
LIFE_EXPECTANCY(-2)	0.017167	0.025119	0.68342	0.52471
LIFE_EXPECTANCY(-3)	-0.07537	0.029214	-2.58014	0.04942
LIFE_EXPECTANCY(-4)	-0.04161	0.024814	-1.67688	0.15441
HDI	0.89570	3.03891	0.29474	0.78003
HDI(-1)	-5.48046	2.65216	-2.06641	0.09366
HDI(-2)	-2.76136	3.49398	-0.79031	0.46515
HDI(-3)	5.352639	3.97790	1.34559	0.23622
HDI(-4)	4.93439	2.57748	1.91442	0.11373
FDI_INFLOWS	0.04283	0.01229	3.48265	**0.01760**
FDI_INFLOWS(-1)	0.02209	0.01515	1.45802	0.20463
FDI_INFLOWS(-2)	-0.03185	0.011944	-2.66727	**0.04449**
FDI_INFLOWS(-3)	-0.01806	0.01175	-1.53699	0.18489
RD	-0.19903	0.23496	-0.84711	0.43559
RD(-1)	-0.18698	0.19352	-0.96616	0.37833
RD(-2)	0.57969	0.19727	2.93854	**0.03231**
RD(-3)	-0.20712	0.26328	-0.78671	0.46708
RD(-4)	-0.62691	0.36824	-1.70244	0.14940
C	2.41677	1.72696	1.39943	0.22056
R-squared	**0.98985**	Mean dependent var		0.91740
Adjusted R-squared	0.94316	S.D. dependent var		0.08005
S.E. of regression	0.01908	Akaike info criterion		-5.18265
Sum squared resid	0.00182	Schwarz criterion		-4.05106
Log likelihood	99.14803	Hannan-Quinn criter.		-4.82823
F-statistic	21.20249	Durbin-Watson stat		2.35932
Prob(F-statistic)	0.00151			

*Note: p-values and any subsequent test results do not account for model selection.

Source: Data processed by Eviews (2024)

Based on the above ARDL estimation results, it is evident that the Life Expectancy variable has a significant influence on the dependent variable, as indicated by a probability value less than 0.05 at lag 1. Lag refers to the number of time periods prior to the current observation that affects the dependent variable. Lag 1 indicates that the effect of the independent variable (Life Expectancy) on the dependent variable occurs after 1 time period. Additionally, the FDI-Inflows variable also has a significant influence with a probability value of 0.01760.

Furthermore, the R&D variable also has a significant influence with a probability value of 0.0321 at lag 2. Similarly to the previous variable, Lag 2 indicates that the effect of the independent variable (R&D) on the dependent variable occurs after two time periods. This suggests that the impact of R&D on the dependent variable does not occur immediately in the same time period, but there may be a time delay before its effects are observed. Of course, the statistical significance of R&D at lag 2 indicates that this variable has a significant influence on the dependent variable during that time period. The results above also indicate an R-Square value of 0.98985, meaning that the independent variables can explain 98% of the dependent variable, while the remaining percentage is influenced by variables outside the model.

4.2. Discussion

The results of this study indicate that the independent variables of life expectancy, FDI inflows, and R&D have a significant positive influence on Total Factor Productivity (TFP). Life expectancy has a significant impact on total factor productivity (TFP) in a country. This study shows that an increase in life expectancy positively affects TFP growth. This is consistent with the research conducted by Usarvas (2020) as shown in studies in Turkey, indicating that better health conditions can indirectly and directly enhance productivity growth.

Longer life expectancy enhances the efficiency of total production factors, leading to economic growth (Kunze, 2014). Additionally, improved health, reflected by higher life expectancy, contributes positively to TFP, emphasizing the importance of investments in health and education for sustainable economic development (Alvi & Ahmed, 2014). Endogenously driven life expectancy, fueled by health investments, plays a crucial role in social welfare and economic outcomes, with increased total factor productivity being key to addressing welfare issues associated with life expectancy. Therefore, enhancing life expectancy through appropriate policies can significantly improve total factor productivity and overall economic growth in a country.

In addition to life expectancy, Foreign Direct Investment (FDI) inflows, referring to the influx of foreign direct capital into a country, also have a significant

impact on TFP. FDI occurs when foreign investors purchase or establish businesses in other countries and have direct control over their business operations. FDI inflows have a significant impact on the recipient economy, particularly in the case of Indonesia. They can bring new technology, best management practices, modern business practices, as well as increase employment opportunities and investment in infrastructure. In the long term, FDI inflows can also enhance economic growth and productivity in the receiving country. This is consistent with research conducted by Sun et al., (2023) in China, which showed that Foreign Direct Investment (FDI) in the producer service sector significantly promotes Green Total Factor Productivity (GTFP) in China, indicating a positive impact on economic and environmental coordination.

However, although FDI has a significant impact in Indonesia and China, the impact of Foreign Direct Investment (FDI) on Total Factor Productivity (TFP) varies across regions. In Latin American countries, FDI inflows are positively related to productivity growth, indicating a high impact on the performance of the analyzed countries (Moreno & Espinosa, 2018). However, in African economies, recent data shows a non-significant long-term effect of FDI inflows on TFP, with other factors such as trade and domestic investment playing a more significant role in determining TFP levels (Musaad et al., 2017). Therefore, while FDI can have a significant impact on TFP in certain regions like Indonesia, China, and Latin America, its influence may not be as clear in other areas such as Africa, where additional factors come into play.

Meanwhile, the most crucial variable in this study, R&D, also has a significant and positive long-term influence. In the long term, investment in R&D plays a vital role in enhancing TFP and the economic growth of a country by stimulating innovation, productivity improvement, and human resource development. Therefore, policies supporting R&D and technological innovation are often considered key to achieving sustainable long-term economic growth. This aligns with research conducted by Zhao & Tian (2022), which shows that both R&D capital stock and R&D personnel specifically can enhance regional TFP, with more pronounced effects in innovation-driven regions compared to investment-driven ones.

Moreover, the positive relationship between TFP and R&D expenditure, especially in the short term, underscores the importance of investing in R&D for sustainable economic growth (Aydin et al., 2018). The spillover effects from R&D contribute to faster TFP growth than from information and communication technology investment, highlighting the direct impact of R&D on productivity (Edquist & Henrekson, 2017). Furthermore, the structure of R&D capital expenditure, particularly the ratio of private to public spending, plays a crucial role in influencing national TFP, with positive changes yielding beneficial effects on productivity (Marire, 2023).

Increased R&D expenditure is also highly essential in Indonesia. This is because R&D expenditure positively impacts company performance and can enhance competitiveness through innovation (Nathanael & Murhadi, 2022). Additionally, Indonesia's low gross domestic expenditure on R&D per capita compared to neighboring countries underscores the need for increased investment to drive innovation and develop new products, as shown in the analysis of the cost-effectiveness of healthcare R&D expenditure (El Khuluqo & Pribadi, 2020). Therefore, enhancing R&D expenditure in Indonesia is crucial for promoting economic growth, innovation, and competitiveness.

Furthermore, the private sector also plays a crucial role in the economy. There are several fundamental principles that underpin the understanding of the crucial role of the private sector. The first principle is Utilitarianism (Eggleston, B., 2022), which asserts that the intrinsic value of an action is determined by its outcome. In the context of R&D, this principle means that investment in R&D can benefit both companies and society. The second principle is Pragmatism (Gillespie, A., et al., 2024), which highlights the importance of the practical application of knowledge. This means that the goal of research and development is to find solutions that can be applied in industries, which in turn can enhance productivity and efficiency. The third principle is Survivalism (Malcolm, N., 2016), which argues that competition is an inherent part of human life. In the context of R&D, this means that companies must be able to innovate and adapt to survive in intense market competition. Following that, the later principle, Habermas' Discourse Principle (Habermas, J., 1996), underscores the significance of dialogue and consensus in enhancing our comprehension of societal needs. In the context of R&D, this principle implies that companies should communicate openly and transparently about the objectives and outcomes of their research and should seek consensus through rational dialogue with all stakeholders involved. Meanwhile, Kant's autonomy principle (Kant, I., et al., 2002) emphasizes the importance of the ability to self-regulate based on rationality. In this context, the private sector should have the freedom to provide input and feedback in policy evaluation processes.

In this economic uncertainty situation, the latter relevant principles proposed by economist Frank H. Knight (Knight, 1921; Audretsch, D.B. and Belitski, M., 2021; Amoroso, S., et al., 2017) are of significant importance context. Knight distinguished between risk, where we can measure probabilities even though outcomes are unknown, and uncertainty, where we cannot know all the information required to accurately gauge measurable probabilities. In the context of research and development (R&D) by the private sector, this principle implies that companies face uncertainty because the outcomes of their R&D efforts are unknown and cannot be precisely measured. This

uncertainty can lead to variations in R&D investment returns, making it crucial for companies to effectively manage this uncertainty. Moreover, in facing uncertain economies, companies may tend to reduce their total R&D investments or switch to short-term projects, potentially sacrificing long-term projects with potentially higher social returns. Therefore, it is essential for governments to consider these factors when formulating policies designed to encourage private sector involvement in R&D. In conclusion, Knight's principle provides a valuable framework for understanding and addressing the challenges faced by the private sector in R&D under economic uncertainty, emphasizing the need for effective government policies to support private sector engagement in R&D.

Amid the current economic uncertainty, increasing Research and Development (R&D) spending in Indonesia is highly crucial as a strategic response. Boosting investment in research and development not only fosters innovation but also strengthens the country's economic resilience. By creating a conducive environment for research and technological advancement, Indonesia has the potential to mitigate the adverse effects of economic volatility. Furthermore, increasing R&D expenditure serves as a proactive step to enhance competitiveness and adaptability, which are essential elements in facing economic turbulence.

Increased investment in research and development (R&D) serves as a push factor in post-COVID recovery, stimulating innovation and creating new products, services, and technologies. This not only opens up new opportunities but also benefits the overall economy. The spillover effects of R&D can lead to productivity improvements and economic growth across various sectors. The multiplier effect comes into play as the initial increase in R&D spending triggers further economic activity. This increased activity stimulates consumer spending, which in turn benefits other types of businesses through spillover effects. Therefore, increased R&D investment not only contributes to economic recovery but also fosters long-term economic growth and prosperity by stimulating market spending and economic activity through multiplier and spillover effects.

In the context of sustainable economic growth and global competitiveness, research and development are fundamental. Amid economic uncertainty, robust R&D initiatives can lead to breakthroughs in addressing pressing social challenges. Indonesia’s demographic condition, characterized by a large productive-age population, presents a unique opportunity for business ventures. Strategic policies are needed to boost productivity and create quality opportunities for this growing working-age population. By investing in human capital and effectively utilizing the productive-age demographic, businesses can identify and capitalize on new market opportunities, driving economic growth and enhancing Indonesia’s global competitiveness. This

approach contributes to the sustainable development of the Indonesian economy.

Affirmative Policy Suggestion for Increasing R&D Expenditure in Indonesia

Affirmative policies aimed at increasing Research & Development (R&D) expenditure is a part of strategic move to enhance Indonesia's economic competitiveness. Business R&D expenditure is the most significant component of total R&D (WIPO, 2023). In this context, the Ministry of Finance (Kemenkeu) plays a crucial role in designing and implementing policies that encourage R&D investment. Here are some suggestions and recommendations related to the affirmative policy for increasing R&D expenditure:

1. Superdeduction Tax Facility

- The Superdeduction Tax facility is an instrument that can be used to encourage companies to engage in R&D. According to Government Regulation (PP) Number 45 of 2019, the government provides a gross income deduction of up to three hundred percent (300%) for those conducting research and development. With this facility, R&D expenses can be deducted up to three times, resulting in significantly reduced or even zero payable taxes if the tax calculation results in a loss.
- Recommendation: The Ministry of Finance (Kemenkeu) should continue to strengthen and promote this Superdeduction Tax facility to companies and research institutions. Educational campaigns and outreach regarding its benefits need to be enhanced.

2. Collaboration with Universities and Research Institutions

- Collaboration between the private sector, universities, and research institutions can increase the effectiveness of R&D. Companies can partner with universities and research institutions to access quality knowledge and human resources.
- Recommendation: Kemenkeu can mediate meetings between companies and universities or research institutions. Special incentive programs for R&D collaborations can also be considered.

3. Monitoring and Evaluation

- Regular monitoring and evaluation of the effectiveness of R&D policies are necessary. Data on R&D achievements and their economic impact should be continuously updated.
- Recommendation: The ministry of finance can establish a dedicated team to

conduct evaluations and prepare periodic reports on the implementation of R&D policies.

CONCLUSION

To advance innovation and competitiveness, Indonesia might strengthen affirmative policies focused on increasing expenditure on research and development (R&D). Collaboration between the Ministry of Finance, the private sector, universities, and research institutions can be key to achieving this goal. Additionally, the private sector is encouraged to conduct thorough market research to identify untapped demand for R&D. Evaluation of R&D expenditure reporting, in the context of data provided by the World Bank, is also essential. With this approach, we can expect Indonesia to continue progressing in the fields of innovation and research.

Banks have the potential to facilitate innovative financing aimed at R&D. By utilizing various financial instruments and products, banks can play a significant role in supporting innovation in R&D. Through this funding, banks can help drive increases in R&D, which in turn can contribute to economic recovery post-COVID. Therefore, the role of banks in facilitating innovative financing for R&D can be a supportive factor in advancing innovation and economic recovery. Islamic banking is expected to play a larger role in the future. This is related to the profit-loss-sharing principle of Islamic financing, which is expected to encourage funding for R&D activities (Juhro et al., 2018).

It is hoped that increased investment in research and development (R&D) will contribute to post-COVID recovery. Greater investment in R&D can open up more opportunities, ultimately benefiting the overall economy during this recovery phase. Thus, increased investment in R&D can be a push factor in post COVID recovery.

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